

[0056] Dynamics Of The Gyroscope

[0057] The dynamics of the idealized model for the gyro: understood in the noninertial coordinate frame associate previously stated, the system 10 is comprised of three ir masses 16, 18, and 20 where each mass can be assum a position vector attached to a rotating reference frame , acceleration in the inertial frame A

$$\vec{a}_A = \vec{a}_B + \dot{\vec{\Omega}} \times \vec{r}_B + \vec{\Omega} \times (\vec{\Omega} \times \vec{r}_B) + 2\vec{\Omega} \times \vec{v}_B$$

[0058]

[0059] where the subscript A denotes "relative to denotes "relative to rotating gyroscope frame B," where and acceleration vectors with respect to the designated respectively, and where $\vec{\Omega}$ is the angular velocity vector

[0096] In the drive mode, the gyroscope 10 is simply a 2-DOF sinusoidal drive force is applied to the first mass 16 (active mass) by drive structures 28. The combination of the second and the third mass 20 comprise the vibration absorber 36 (passive mass) of the oscillator mechanically amplifies the oscillations of mass 16. Approximating the 10 by a lumped mass-spring-damper model as shown in Fig. 5(a), the motion in the drive direction can be expressed as

$$\begin{aligned} m_1 \ddot{x}_1 + c_1 \dot{x}_1 + k_1 x_1 &= k_2 (x_2 - x_1) + F_d \\ (m_2 + m_3) \ddot{x}_2 + c_2 \dot{x}_2 + k_2 x_2 &= k_2 x_1. \end{aligned} \quad (2)$$

[0097]

[0098] When a constant-amplitude sinusoidal force $F_c = F_0 \sin \omega t$ is applied on the active mass 16 by the interdigitated comb-drives 28, the state response of the system 12 as illustrated by graph Fig. 6(a) will be in the equation,

sense-mode oscillator become

$$\begin{aligned} m_2 \ddot{y}_2 + c_{2y} \dot{y}_2 + k_{2y} y_2 &= k_{3y} (y_3 - y_2) + 2m_2 \Omega_z \dot{x}_2 \\ m_3 \ddot{y}_3 + c_{3y} \dot{y}_3 + k_{3y} y_3 &= k_{2y} y_2 + 2m_3 \Omega_z \dot{x}_2. \end{aligned} \quad (3)$$

[00107]

[00108] The response of the system to a constant-amplitude force is similar to that of the drive-mode oscillator as illustrated in Fig. 6(b), with the resonant frequencies of the isolated active and passive spring systems of $\omega_{2y} = (k_{2y}/m_2)^{1/2}$ and $\omega_{3y} = (k_{3y}/m_3)^{1/2}$ respectively. The frequency of the sinusoidal Coriolis force is matched with the resonant frequency of the isolated passive mass-spring system 40, the passive mass 20, to achieve maximum dynamic amplification.

[00109] The most important advantage of decoupling the drive and sense-mode oscillator 36 is that the Coriolis force that excites element 20 is not generated by the sensing element 20. Instead, $F_{20} = 2m_2 \Omega_z dx_2/dt$ generated by mass 18 excites the active mass 16. The oscillator dictates that the passive mass 20 has to be minimized to maximize its oscillation amplitude. Since the Coriolis Force $F_{c3} = 2m_3 \Omega_z dx_3/dt$ generated by mass 20 is not required to be large, the sensing element 36 can be designed to have a large mass.